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ABSTRACT

Two intermediate algebra classes at a large university were selected for this study comparing increase in mathematics achievement for students enrolled in a course that used either traditional lecture approach or a traditional lecture approach plus a mastery learning laboratory. The laboratory was staffed by tutors who administered and graded unit tests and provided tutoring. Students were required to pass unit tests with scores of at least 90% before taking the next unit test; if not, they returned later to take another version of the test. Students were assessed pre- and post-instruction in terms of achievement and attitudes toward mathematics. Findings indicated that the students in the mastery learning plus lecture approach achieved higher final examination scores and tended to have higher scores on a standardized algebra test when prior mathematics background was held constant. They also tended to have a more positive attitude toward mathematics and greater awareness of the importance of mathematics than did those students in the lecture-only approach. Implications for teacher education programs are discussed. (JD)

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DIFFERENCES BETWEEN A GROUP USING A TRADITIONAL FORMAT WITH MASTERY LEARNING AND A GROUP USING A TRADITIONAL FORMAT ONLY IN DEVELOPMENTAL MATHEMATICS COURSES AT THE UNIVERSITY LEVEL: IMPLICATIONS FOR TEACHER EDUCATION PROGRAMS

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PRECIS

Differences Between a Group Using a Traditional Format with Mastery Learning and a Group Using a Traditional Format Only in Developmental Mathematics Courses at the University Level: Implications for Teacher Education Programs

This study compared students' achievement and attitudes toward mathematics in developmental mathematics classes using a mastery learning format with classes using a traditional format. When multiple regression analyses were conducted, significant differences in achievement and in perceptions of importance in mathematics were found.

DIFFERENCES BETWEEN A GROUP USING A TRADITIONAL FORMAT WITH MASTERY LEARNING AND A GROUP USING A TRADITIONAL FORMAT ONLY IN DEVELOPMENTAL MATHEMATICS COURSES AT THE UNIVERSITY LEVEL: IMPLICATIONS FOR TEACHER EDUCATION PROGRAMS

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Developmental studies and remedial courses have become increasingly familiar terms in higher education during the last ten years. Test scores indicate that many college freshmen are not fully prepared for the university-level mathematics courses required in their major programs. As a result, more than 80 percent of American colleges and universities now offer either developmental or remedial courses in basic skills to entering freshmen (Nielson and Polishook, 1984). This percentage seems to be increasing; the Board of Regents of the State University and College System of Tennessee, for example, recently mandated that developmental and remedial courses be offered at each of its institutions of higher education (State University and College System of Tennessee, 1984).

College and university students seem to be taking advantage of the remedial opportunities provided by their institutions. Enrollments in developmental and remedial courses increased by 72 percent from 1975 to 1980 Crosswhite, Demana, Leitzel, & Osborne, 1984). Many of these students were education majors. In the recent **Report on Excellence in Undergraduate Education** a recommendation was made that institutions should offer remedial courses and programs when necessary but should set standards and employ instructional techniques in those programs that will enable students to perform well subsequently in college-level courses.

The specific strategies and policies to improve rates of student persistence and success include the following:

1. Students assigned to remedial programs should carry limited course loads, but they should be encouraged to include at least one course per semester in an area of academic interest to them.

2. Remedial courses should be accompanied by a variety of means (including support groups and greater use of peer tutors) to enhance students' self-esteem, academic identity, and sense of direction in life.

3. Remedial programs should place heavy emphasis on communications skills, and on reading, writing, and listening skills in particular.

4. In no case should final standards of performance in remedial courses in English and Mathematics be normed at less than twelfth grade levels.

Remedial programs are not a new phenomenon in American higher education. In the nineteenth century, many colleges and universities operated "preparatory departments" that provided instruction in precollege subjects not offered in secondary schools of the time. But as higher education has expanded in recent years, entering students have become more diverse in their preparation. The study group recommends that remedial programs can and should work while respecting the standards for college-level performance that should be behind the baccalaureate degree (Involvement in Learning: Realizing the Potential of American Higher Education, 1984).

Effective instructional strategies are urgently needed to ensure the success of students in university-level mathematics courses. Especially important is the need to increase the understanding of mathematics concepts of students enrolled in teacher education programs. The lack of comprehension of elementary mathematical concepts by preservice teachers can only lead to the perpetuation of the lack of mathematical abilities in their own students when they become teachers.

Instructional strategies must be directed toward accomplishing a two-fold

purpose: (1) improving mathematical skills for success in college-level mathematics courses, including mathematics courses for elementary teachers, and (2) improving students' attitudes toward mathematics. Positive attitudes may encourage students to take additional college-level mathematics courses and to pursue quantitatively-oriented careers, including the teaching of mathematics, either at the elementary or secondary level.

Aiken (1970) noted that attitudes can predict which courses a student will select and whether one will persist in a given mathematics class. Brassell, Petry, and Brooks (1980) notes that teachers must be made aware that their behaviors in the classroom have affective as well as cognitive results upon the performance of their students.

> Teachers should be aware of the fact that the teacher's attitudes toward mathematics and mathematics students are recognized by their pupils and may be the determinants of pupils' attitudes toward mathematics (p. 28).

Developmental students, by definition, enter college with a lack of basic skills needed to compete in regular college courses; since many students majoring in education are enrolled in developmental courses, it is important that they acquire those skills they expect to teach. One approach that lends itself to developing essential mathematical skills needed for college-level coursework is mastery learning.

Mastery learning was used as early as the 1920's by instructors in an effort to increase comprehension and skills. Dr. Benjamin S. Bloom, of Northwestern University, is generally credited with the development of an instructional theory built on mastery learning (Block, 1971).

Numerous educators have advocated the use of mastery learning in educational settings. Leonard (1984) provides a convincing argument for the use of mastery learning in all schools as a component of the reforms necessary

to improve education dramatically. Begle (1979) reports that mastery learning appears to produce good results at the college level. Despite the fact that mastery learning is considered by many to be a powerful educational tool, few educational institutions have implemented it in the learning process. Furthermore, this technique is rarely, if ever, mentioned in methods of teaching mathematics courses.

Mastery learning means that students given a sequence of tasks or concepts must show proficiency of one task or concept before being permitted to proceed to the next one. Bloom, Hastings, and Madaus (1971) contend that 95 percent of students, under appropriate conditions which allow enough time, can achieve mastery of a learning task using the grade of A as an index of the mastery concept. They state that strategies for mastery learning include determining ways of altering the amount of time provided individual students for learning, as well as finding ways to provide whatever time each student needs.

The provision of immediate feedback on performance and corrective assistance is incorporated into the mastery learning format (Block, 1971). Bloom, Hastings, and Madaus (1971) advocate the use of tutors to provide this feedback and tutorial assistance. They state that " . . . if every student had a very good tutor, most of them would be able to learn a particular subject to a high degree" (p. 47).

Bloom, Hastings, and Madaus contend that mastery learning can produce positive outcomes in the affective domain as well as in the cognitive domain. The clearest evidence of affective change is that students begin to develop an interest in the subject mastered. They state, he [the student] begins to 'like' it and to want more of it. . . . The student desires some control over his environment, and mastery of a subject gives him some feeling of

control over a part of his environment" (p. 56). They further state that, at a deeper level, a student's self-concept and his confidence level are improved.

This study compares achievement in basic mathematical skills of students who participated in the mathematics mastery learning program to the achievement of students enrolled in classes that employed a lecture-only approach for teaching mathematics. Attitudes toward mathematics were also assessed for both groups.

METHOD

Sample

Developmental Studies students at the University of Georgia are those students who have not met the university's minimum admission standards based on a sliding scale of Scholastic Aptitude Test (SAT) scores and high-school grade point averages (GPA). All developmental mathematics students took the State of Georgia Basic Skills Examination (BSE). Students who scored 80% or greater on the BSE were given the Intermediate Algebra Skills Examination (IAS) (Educational Testing Service, 1978). Those who scored between 60% and 70% on the IAS were placed in the Level II courses. All other students were either placed in a lower level or were admitted into regular university mathematics classes and were exempted from the present study.

An instructor who taught Level II mathematics classes randomly selected one of her classes to be taught through a traditional lecture approach and one to be taught with a traditional lecture approach plus a mastery learning laboratory. Thirty-six college freshmen enrolled in these two classes. Sixty-one percent were female, and 39% were male; 3% were minority students. The

mean SAT Mathematics (SATM) score for the total group was 439. These students had an average of 3.6 high-school mathematics courses (HSCOURSES) beginning with first-year algebra. Table 1 shows the means and standard deviations for each group's number of HSCOURSES, SATM scores, final examination scores, IAS scores, pre- and post-instructional attitudes toward mathematics scores, and pre- and post-instruction scores on importance of mathematics.

Variables

Two Likert-type scales were used, which dealt with student perceptions of mathematics. One consisted of items from the Inventory of Affective Aspects of Schooling (IAAS) by Haladyna and Shaughnessy (1982). The items from the IAAS measured general attitudes toward mathematics and consisted of four items, each item being a five-point rating scale with responses ranging from very unhappy to very happy. The items were as follows:

how do (did) you feel . . .

when it is time for mathematics?

during mathematics?

if you knew you would never go to mathematics again?

when mathematics is over?

Coefficient alpha, which is an internal consistency reliability estimate (Haladyna & Thomas, 1979), ranged between .74 and .89.

The other scale of attitude was the V Scale Aiken (1974) devised to measure a student's perception of the importance of mathematics. The scale consisted of 10 items such as "mathematics is less important to people than art or literature" and "mathematics is needed in designing practically everything." Each item was a five-point rating scale with responses ranging from strongly disagree to strongly agree. Coefficient alpha was .85 for the V scale

(Aiken, 1974).

The IAS examination was also administered as a post-test. Multiple choice items pertained to standard topics in algebra such as determining the equation of a line when given two points, factoring a trinominal, and finding the distance between two given points.

The number of high-school mathematics courses completed by students, beginning with first-year algebra, was determined by examining the students' high-school transcripts. Only courses such as algebra, geometry, trigonometry, and calculus were considered; courses such as "Mathematics for Daily Living" were not considered.

The instructor constructed a comprehensive final examination consisting of approximately 25 items. The problems were on standard algebraic topics requiring students to determine the appropriate algorithm and carry it out accurately. Topics such as simultaneous equations, equations containing fractional algebraic terms or absolute values, quadratic equations, word problems, determinants, etc., were included in the items. The examination paralleled a standard second-year algebra final examination and was open-ended in format.

Procedures

The instructor taught students in the lecture group in a traditional format, presenting lectures and administering regularly-scheduled unit tests during class time. The mastery learning group went to a mathemetics laboratory for testing. There, peer tutors (upperclass undergraduates who were paid to provide tutoring services) administered and graded the unit tests. These tutors had received special training and were supervised by the mathematics laboratory coordinator. After administering and grading the tests with the student

present, the tutors gave immediate feedback and corrective assistance to the students on the items missed. The instructor required students to make 90% or better on a unit test before being allowed to take the next unit test. If 90% was not achieved, the students returned to the laboratory on another day and took a similar version of the test and continued this process until 90% mastery was achieved. Some students had to take as many as six different versions of a test before achieving mastery. The average number of times a student took a version of a unit test was three.

Students in both groups took a single teacher-made midterm and a single teacher-made final examination. Students were not permitted to retake the midterm or the final examination.

Analysis of Data

Multiple regression was used to analyz the data. This method examined differences in the slopes and intercepts of regression lines which represented group membership (mastery learning plus lecture versus lecture approach), while holding constant various pre-instruction measures of mathematical achievement and student perceptions related to mathematics. The sequential procedure for comparing regression lines recommended by Pedhazur (1982, pp. 449-450) was used; a test for intercept differences was followed by a test for slope differences when there was failure to detect departures from parallelism in the regression lines. The test for slope differences was a test for possible interaction between the pre-instruction measure and group membership, and it was determined the pre- and post-instruction measures were related in the same manner for both groups. Failure to ascertain significant interaction permitted the test of group differences on the post-instruction measures. The Appendix reports the regression models.

Analysis One. Test for interaction between group membership and covariate SATM and HSCOURSES) in predicting final exam score and algebra test score (IAS).

Analysis Two. Test for group membership differences on the final exam and algebra test, while holding constant simultaneously the SATM and HSCOURSES.

Analysis Three. Test for interaction between group membership and the covariate of pre-instruction mathematics attitude in predicting post-instruction mathematics attitude. Test for interaction between group membership and the covariate of preinstruction importance of mathematics in predicting post-instruction importance of mathematics.

Analysis Four. Test for group membership differences on the post-instruction mathematics attitude and importance of mathematics measures while holding constant, respectively, pre-instruction mathematics attitude and pre-instruction importance of mathematics.

Results

Table 1 reports the means and standard deviations of the variables for each group. The results of the tests for interaction between group membership and pre-instruction measures indicated that none of the interactions were statistically significant. This lack of interaction fulfilled an important assumption of the analysis of covariance and permitted the examination of group differences while holding constant pre-instruction measures.

The test for intercept differences indicated that the mastery learning group scored significantly higher than the lecture group on the final exam while holding constant the SATM and HSCOURSES, F (1, 32) = 14.52, $P < .01$. However, there were no significant differences between the groups on the IAS test. The mastery-learning group scored higher on the post-instruction

measure of the importance of mathematics while holding constant the pre-instruction measure of the importance of mathematics, $F(1, 33) = 6.13$, $P < .05$. There were no significant group differences on the post-instruction mathematics attitude measure.

Discussion

The purpose of this study was to compare the increase in mathematics achievement for developmental studies students enrolled in a one-quarter course that used a mastery learning plus lecture approach with those enrolled in a traditional lecture course. Attitudes toward mathematics and awareness of the importance of mathematics were compared between the two groups.

The findings indicated that the students in the mastery learning plus lecture course performed significantly better on the final examination than the students in the traditional lecture course when prior mathematics background (SATM and HSCOURSES) was held constant. Group membership accounted for 30% of the variance in the final exam scores when the variability due to the SATM and HSCOURSES was parcelled out of the final exam scores. This amount of explained variability in the final examination scores, attributed to group membership, is a rather large effect size.

There were no statistical differences between the two groups on the IAS test when prior mathematics background was held constant. Group membership accounted for 8% of the variability in the IAS scores with the mastery learning group achieving higher scores. This difference, however, was not statistically significant.

The statistical power for the present study was not very high. The power to detect an effect size of .087 at alpha = .05 was .38. Thus, if an effect size of .087 truly represented the effect in the population, it would be detected as being statistically significant 38 out of 100 times with the

present sample size. A sample size of about 200 would be needed in order to increase power to .80 for an effect size of .087.

Students who participated in the mastery learning plus lecture approach appeared to feel an increased awareness of the importance of mathematics. Group membership accounted for 12% of the variability in post-instruction scores on the importance of mathematics. While the attitude toward mathematics was not significantly better for the mastery learning students, group membership did account for 3% of the variability in mathematics attitude scores.

The present study suggested that developmental mathematics students in a mastery learning plus lecture approach achieved higher final examination scores and tended to have higher scores on a standardized algebra test when prior mathematics background was held constant. Moreover, students in the mastery learning plus lecture group tended to have a more positive post-instruction attitude toward mathematics, and from a statistical viewpoint, had significantly greater awareness of the importance of mathematics than did those students in the lecture-only approach.

Implications

Remedial education has had difficulty achieving acceptance as an effective support system for academic programs in higher education. The reasons for this situation may be traced to two main factors: execution and economics. First, unlike other programs in higher education, remedial services have been slow to deliver desired outcomes to so-called regular academic programs. Second, remedial education has been hindered by the lack of consistent funding at many universities. With the recent enactment of

mandated admission requirements for teacher education programs in some 35 states, mastery learning holds promise for preservice teachers who may be deficient in mathematics.

Recommendations for considering the extension of mastery learning to existing teacher education programs logically include: computer aided instruction, peer tutoring programs, and infusion into courses other than those considered remedial. Computer assisted instruction is frequently employed to monitor instruction and evaluate performance--essential precepts of mastery learning. The high touch interaction effects of peer tutoring and the sophistication of hi-tech computer aided instruction are likely to produce positive, cost efficient learning results. Paid peer tutors may be supplemented by other forms of mastery teaching. One institution, for example, uses unpaid student volunteers to tutor peers in mathematics. Mastery learning also has potential application for a myriad of teacher education classes requiring competence at a specified level of mastery.

TABLE 1

Variable Means and Standard Deviations

Variable	Lecture Only n = 18 M	Lecture Only n = 18 SD	Mastery Learning n = 18 M	Mastery Learning n = 18 SD
1. SAT (Math)	446.0	52.00	432.0	50.0
2. High School math courses	3.7	0.67	3.6	3.2
3. Final exam	80.0	9.00	89.0	5.0
4. Algebra test	26.0	2.40	27.0	2.0
5. Pre-math attitude	1.6	0.61	1.9	0.52
6. Post-math attitude	1.9	0.64	2.3	0.53
7. Pre-importance of math	3.1	0.39	3.0	0.61
8. Post-importance of math	3.0	0.38	3.2	0.50

APPENDIX

Test for slope differences

1. Full model for dependent variables: algebra test, final exam

$$Y_{1,2} = a_0U_1 + a_1X_1 + a_2X_2 + a_3X_3 + a_4X_4 + a_5X_5 + e$$

Restricted model:

$$Y_{1,2} = a_6U_2 + a_7X_1 + a_8X_2 + a_9X_3 + e$$

2. Full model for dependent variable: mathematics attitude

$$Y_3 = a_{10}U_3 + a_{11}X_1 + a_{12}X_6 + a_{13}X_7 + e$$

Restricted model:

$$Y_3 = a_{14}U_4 + a_{15}U_1 + a_{16}X_6 + e$$

3. Full model for dependent variable: importance of mathematics

$$Y_4 \quad a_{17}U_5 + a_{18}X_1 + a_{19}X_8 + a_{20}X_9 + e$$

Restricted model:

$$Y_4 = a_{21}U_6 + a_{22}X_1 + a_{23}X_8 + e$$

Test for Intercept Differences

1. Full model for dependent variables: algebra test, final exam

$$Y_{1,2} = a_6U_2 + a_7X_1 + a_8X_2 + a_9X_3 + e$$

Restricted model:

$$Y_{1,2} = a_{24}U_7 + a_{25}X_2 + a_{26}X_3 + e$$

2. Full model for dependent variable: mathematics attitude

$$Y_3 = a_{14}U_4 + a_{15}X_1 + a_{16}X_6 + e$$

Restricted model:

$$Y_3 = a_{27}U_8 + a_{28}X_6 + e$$

3. Full model for dependent variable: importance of mathematics

$Y_4 = a_{21}U_6 + a_{22}X_1 + a_{23}X_8 + e$

Restricted model:

$Y_4 = a_{29}U_9 + a_{30}X_8 + e$

a - Partial regression weight

U - Intercept

X_1 - Group: 1 if mastery learning; 0 if lecture

X_2 - SAT mathematics score (SATM)

X_3 - Number of high school mathematics courses (HSCOURSES)

X_4 - Group * SATM

X_5 - Group * HSCOURSES

X_6 - Pre-instruction mathematics attitude

X_7 - Group * pre-instruction mathematics attitude

X_8 - Pre-instruction importance of mathematics

X_9 - Group * pre-instruction importance of mathematics

Y_1 - Algebra test scores

Y_2 - Final exam scores

Y_3 - Post-instruction mathematics attitude

Y_4 - Post-instruction importance of mathematics

e - error

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